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Seasonal Habitat Suitability Model of Bezoar Goat (*Capra aegagrus*) in Artvin, Türkiye

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ABSTRACT

Habitat suitability models are frequently used in wildlife to predict suitable areas for species. Bezoar goat (Capra aegagrus) is an important species with a relatively wide distribution and is found in different habitats in Türkiye. Artvin-Meydancık game reserve is an important area for the bezoar goat with different habitat structures. Habitat suitability modeling is essential for the effective conservation and management of the species. Habitat suitability modeling was performed with the MaxEnt method using bio-climate data, environmental data, slope, elevation, ruggedness, land cover data, and presence data obtained through regular inventory and field observations. Based on the model results, the most suitable areas for the mating season of the Bezoar goat were identified as high-slope areas with altitudes between 400 and 1100 m and coniferous forests with openings. The mean bezoar goat population size was estimated as 248 individuals. The study is crucial for bringing a different approach to the practitioners in terms of using habitat suitability models in the planning of game reserves.

INTRODUCTION

Different habitat suitability modeling studies have been conducted for the Bezoar goat (Capra aegagrus) to determine potential distribution areas (Uçarlı, 2016), to evaluate the contributions of seasonal variables to model performance (Zenbilci *et al*., 2024), and to assess the importance of environmental factors such as annual temperature range, terrain ruggedness, and seasonal precipitation (Acarer, 2024). Other models have demonstrated that field-based occurrence data can generate highly predictive habitat suitability outputs (Rahim, 2016) and have also examined the influence of predator pressure on habitat selection (Morovati *et al*., 2014).

Beyond studies focused specifically on Bezoar goat, similar modeling approaches have been applied to different game species (Süel, 2014) and carnivores, such as brown bears, to classify habitat suitability and propose conservation measures (Yüksel & Ambarlı, 2024). Collectively, these studies demonstrate that the MaxEnt (Maximum Entropy) algorithm has become one of the most widely used and effective tools for predicting habitat suitability across species and ecosystems.

MaxEnt estimates habitat suitability based on the relationship between known occurrence points and environmental variables, producing potential distribution maps that indicate areas most suitable for the focal species (Booth *et al*., 2014; Rafatpey *et al*., 2023; Yackulic *et al*., 2013).

Bezoar goat typically occupy rugged landscapes consisting of valleys and ridges 3–5 km in length and 500–800 m in width, with individual home ranges of approximately 150–400 ha (Gündoğdu, 2006). Bezoar goat is commonly found in steep rocky areas, caves, dense shrubs, and at elevations exceeding 1 500 m (Çanakçıoğlu & Mol, 1996). In northeastern Anatolia, Bezoar goats have been observed to prefer rocky, south-facing slopes but also utilize lower elevations (<900 m) when suitable cover is available (Uçarlı, 2016). In southern Türkiye, they have been reported to favor ecotone habitats between Pinus brutia stands and open areas, as well as shaded zones within Quercus coccifera communities (Gündoğdu, 2006).

In the Caucasus, Bezoar goat populations are highly fragmented and remain under significant hunting pressure despite the presence of suitable habitats, which hinders population recovery and range expansion (Kuemmerle *et al*., 2020). Similarly, illegal hunting pressure remains a persistent threat to northeastern Anatolian populations (Uçarlı, 2016). A study from Dagestan reported marked sexual segregation in habitat use, with slope aspect, elevation, and vegetation cover significantly influencing male and female distributions (Magomedov *et al*., 2002). These findings suggest that ecological and physiological differences among age and sex classes drive spatial distribution patterns, highlighting the need for habitat-based conservation planning. Furthermore, strong links exist between habitat suitability, population viability, and conservation strategies (Larson *et al*., 2004).

Identifying suitable habitats remains critical in areas exposed to intense anthropogenic pressures, particularly illegal hunting. Bezoar goat, which are subject to hunting quotas, ecological population densities are often estimated based on the availability of suitable habitats. Therefore, the present study aims to identify and map suitable habitats for the bezoar goat within the Artvin-Meydancık Game Reserve-characterized by variable elevation and diverse vegetation-using the MaxEnt modeling approach.

Presence-only habitat suitability models have been

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recognized as cost-effective tools for producing high-quality predictive outputs without extensive field sampling (Muñoz *et al.*, 2015). Instead of conducting long-term and resource-intensive habitat measurements, this study used occurrence data derived from systematic inventory and field observations to construct habitat suitability models at the game reserve during the mating season. The objective was to identify spatial patterns of habitat suitability and to define mating areas that are most critical for effective management and conservation of Bezoar goats in the region.

MATERIAL AND METHODS

Study Area

The study was conducted in the Meydancık Game Reserve, located in the Artvin Province, northeastern Türkiye. The reserve covers an area of approximately 59,704 ha, encompassing diverse elevation gradients, stream systems, coniferous and deciduous forests, mixed stands, and forest clearings that together form a highly heterogeneous habitat mosaic (Fig. 1).

The topography of the study area is predominantly mountainous and rugged, characterized by alpine meadows and rocky slopes. The main forest components include Oriental spruce (Picea orientalis) and Caucasian fir (Abies nordmanniana) as dominant coniferous species, while Oriental beech (Fagus orientalis) and oak species (Quercus spp.) represent the principal deciduous elements.

Climatically, the reserve lies within the transition zone between humid and continental regimes, exhibiting the general climatic features of the Eastern Black Sea region. Due to its altitudinal and vegetational diversity, the area provides suitable habitats for several large mammal species, including the chamois (Rupicapra rupicapra), roe deer (Capreolus capreolus), brown bear (Ursus arctos), gray wolf (Canis lupus), Eurasian lynx (Lynx lynx), and wild boar (Sus scrofa) (Anonymous, 2020).

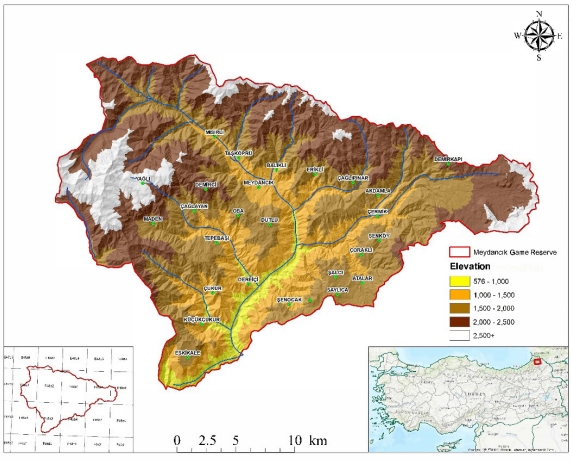


Figure 1: Location and elevation map of the Meydancık Game Reserve-Artvin, Türkiye

Field Surveys and Data Collection

Population inventory and field observations were conducted in coordination with the 12th Regional Directorate of Nature Conservation and National Parks and the Artvin Branch Directorate between 2018 and 2024. Data were collected annually during the mating season (November–December) within the Artvin-Meydancık Game Reserve, using the point count method as the primary survey approach.

A total of 34 observation points were established across dominant vantage areas where Bezoar goat populations were known or expected to occur, ensuring optimal visibility and spatial coverage (Fig. 2). Simultaneous counts were performed at all stations, and observed individuals were directly recorded in standardized census forms. The surveys were conducted using binoculars and telescopes from high vantage points, allowing effective sampling of approximately 8,000 ha, representing 13% of the total reserve area.

The count results were treated as raw observation data and the minimum observed population estimates were derived from actual sightings. Based on the number of individuals recorded at each point, population size and density were calculated for the surveyed area. Additionally, the primary habitat structures within the study area were identified and mapped using Geographic Information Systems (GIS) to support spatial analysis of habitat suitability.

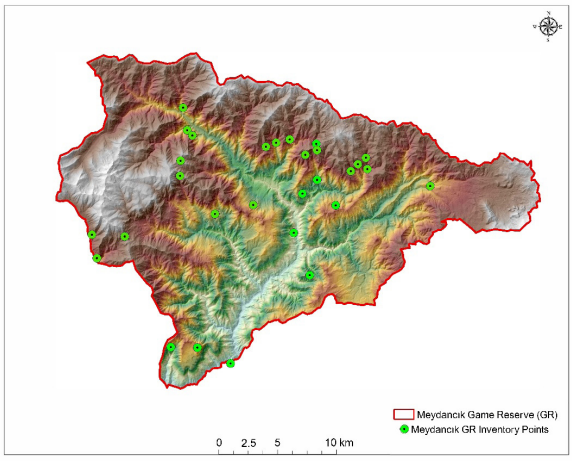


Figure 2: Observation and inventory points in the Artvin-Meydancık Game Reserve.

Environmental Variables and Habitat Modelling

Environmental variables influencing the habitat use of the Bezoar goat (Capra aegagrus) include land cover, slope, elevation, terrain ruggedness, aspect, and proximity to water sources (Acarer, 2024; Morovati *et al.*, 2014; Rahim, 2016; Süel, 2014; Uçarlı, 2016). The environmental parameters used in the present study were selected based on previous research to accurately represent the ecological conditions relevant to the

species' habitat requirements (Acarer, 2024; Süel, 2014; Uçarlı, 2016).

For modeling, global climate data were obtained from the WorldClim database (https://www.worldclim.org), while bioclimatic variables (temperature, precipitation, and humidity) were incorporated alongside topographic and land cover data (https://corinecbs.tarimorman.gov.tr). Except for land cover data, all topographic variables (slope, elevation, ruggedness, and aspect) were derived from Digital Elevation Models (DEMs) using ArcGIS software.

Habitat suitability modeling was performed using MaxEnt software, incorporating species occurrence data obtained from field inventory points, environmental layers, and climate datasets. Climatic factors such as temperature, precipitation, and humidity, derived from long-term averages, were included due to their strong influence on vegetation patterns and, consequently, on Bezoar goat habitat selection. To prevent multicollinearity, only non-correlated bioclimatic variables consistent with regional climatic conditions were retained in the final model.

Within the game reserve, forest stand structures and site characteristics from locations where the species was observed were used to refine the model and evaluate habitat use. Before model execution, modifications were made to the default MaxEnt settings following approaches adopted in similar studies (Acarer, 2024; Süel, 2014; Yüksel & Ambarlı, 2024). The random test percentage was set to 25%, and subsampling was used as the replication method. The maximum number of iterations was defined as 500, and the model was run across five replicate datasets to ensure consistency and robustness of predictions. Following model completion, the area of each habitat suitability class was calculated using ArcGIS, providing a spatial quantification of suitability levels within the Meydancık Game Reserve.

Table 1: Area distribution of Bezoar goat habitat suitability classes

Habitat Suitability (%)	Habitat Suitability Class	Area (ha)	Area (%)
0–10	Unsuitable	21,860	37%
10–20	Unsuitable	6,896	12%
20–30	Unsuitable	6,125	10%
30–40	Slightly Suitable	5,033	8%
40–50	Slightly Suitable	3,486	6%
50–60	Moderately Suitable	4,195	7%
60–70	Moderately Suitable	3,937	7%
70–80	Highly Suitable	3,099	5%
80–90	Highly Suitable	2,583	4%
90–100	Highly Suitable	2,490	4%
Total		59,704	100%

RESULTS AND DISCUSSIONS

Habitat Suitability Model of Bezoar Goat

Habitat suitability model of Bezoar goat (Capra aegagrus) suggested that approximately 8,172 ha of the study area were classified as highly suitable (70–100%), 8 132 ha as moderately suitable (50–70%), 8 519 ha as marginally suitable (30–50%), and 34 881 ha as unsuitable (<30%) for the species. Overall, areas with suitability values ≥50% accounted for only 27% of the total game reserve area (Table 1 and Fig. 3).

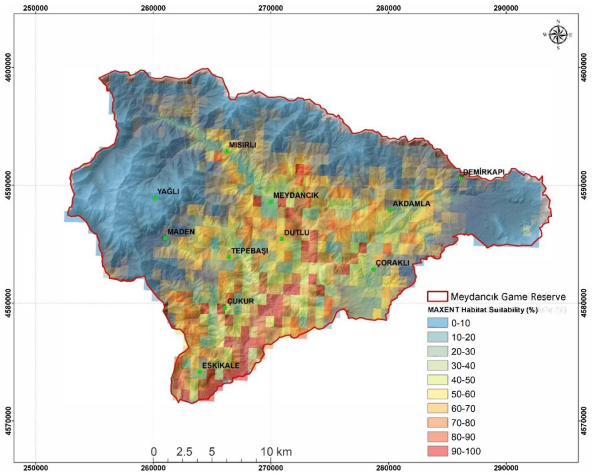


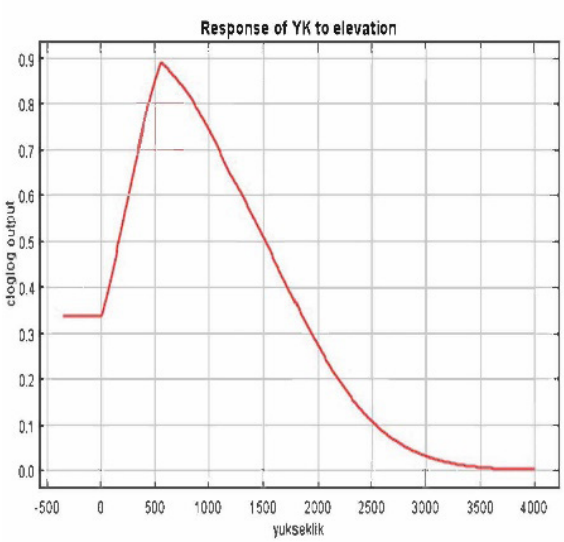
Figure 3: Bezoar Goat habitat suitability map of Artvin-Meydancık Game Reserve.

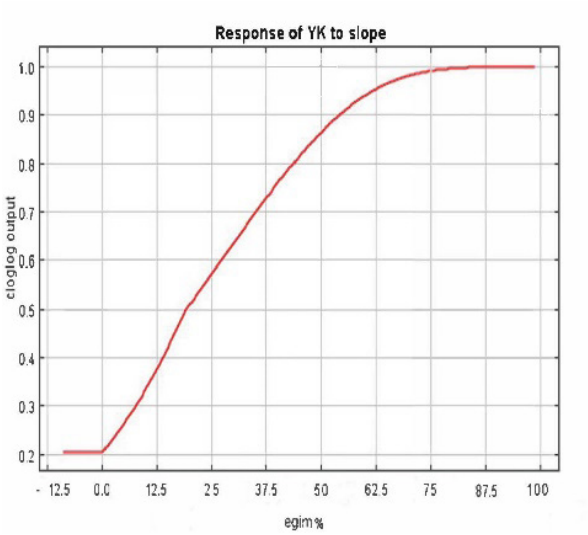
The MaxEnt model results indicated that the most suitable elevation range for the Bezoar goat was between 400 and 1100 m. Habitat suitability increased with elevation up to approximately 550 m, beyond which it gradually declined. Suitability dropped to around 50% at 1,500 m and fell below 10% above 2,500 m (Fig. 4).

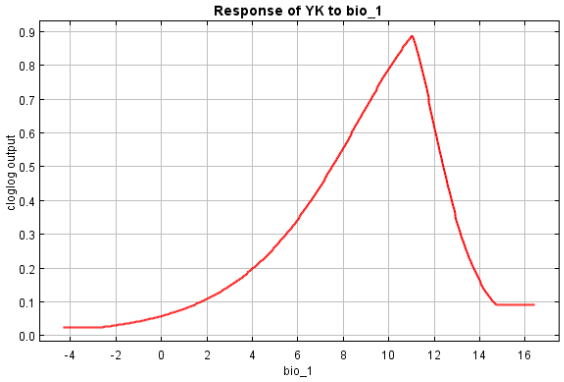
The relationship between slope and suitability showed that habitat suitability increased with slope up to about 87.5%, suggesting a clear preference for steep terrain. In contrast, relatively flat areas were found to be less suitable. At approximately 35% slope, habitat suitability reached around 70%. In terms of climatic factors, the model revealed that habitat suitability peaked at a mean annual temperature of approximately 11 °C. Suitability declined sharply at lower temperatures, dropping below 10% when the mean annual temperature fell below 2 °C (Fig. 4).

Variable Importance and Model Interpretation

The Jackknife analysis of the Bezoar goat suitability model revealed that the most influential bioclimatic variables were, in descending order of importance: Bio5 (maximum temperature of the warmest month), Bio10 (mean temperature of the warmest quarter), Bio6 (minimum temperature of the coldest month), and Bio2 (mean diurnal temperature range) (Fig. 5). In addition







to these climatic variables, elevation, slope, land cover (CORINE), and forest type were also identified as significant contributors to the model.

Population Dynamics of Bezoar Goat

The results of these inventories are presented in Figure 7. During the inventory periods, a minimum of 136 individuals was recorded in 2024 and a maximum of 374 individuals in 2019, with an average of 248 individuals. Based on the total area of Meydancık game reserve, the absolute population density was calculated as 0.41 individuals/100 ha. When considering only the areas with ≥50% suitability for the target species, covering 16,304 ha, the ecological population density was estimated at 1.52 individuals/100 ha. Population structures generally show stability. However, in many habitats, factors such as illegal hunting, food competition, predator-prey interactions, changing climatic conditions, and natural disasters can cause significant fluctuations in population size.

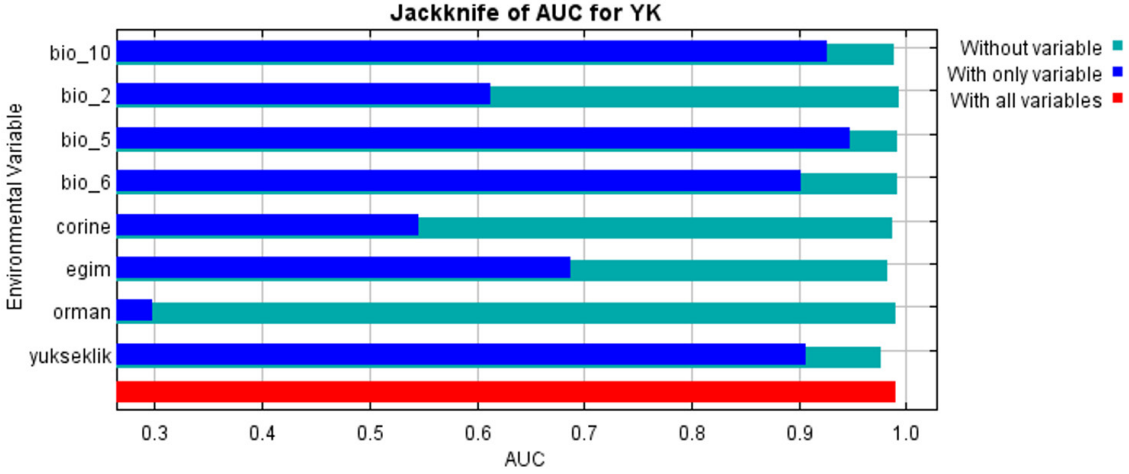


Figure 5: Jackknife test results of relative contribution of environmental and bioclimatic variables to the bezoar goat habitat suitability model

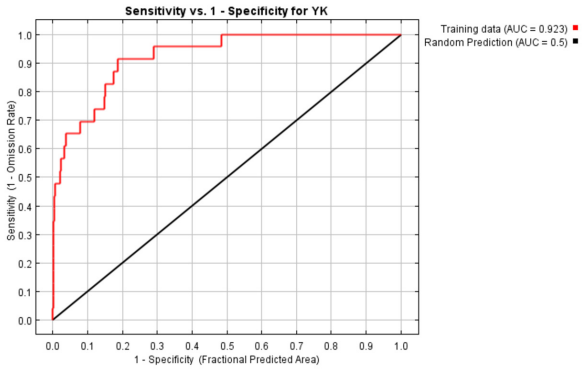


Figure 6: Sensitivity curve of the bezoar goat habitat suitability model

RESULTS AND DISCUSSION

Habitat Modelling and Spatial Pattern

The habitat model confirmed that elevation, slope, and temperature are critical factors determining habitat suitability for Bezoar goat. The preference for steep slopes aligns with previous studies (Morovati *et al.*, 2014; Uçarlı, 2016), which suggest that rugged terrain offers both safety from predators and optimal visibility. Despite general assumptions that Bezoar goats prefer higher elevations, this study found highest suitability between 400 and 1,100 m during the mating season, suggesting seasonal altitudinal shifts likely driven by thermoregulation and habitat access.

The influence of temperature-related variables (Bio5 and Bio10) is consistent with studies from both Mediterranean and northeastern regions of Türkiye (Acarer, 2024; Zenbilci *et al.*, 2024), where seasonal climate plays a crucial role in determining goat distribution.

Only 27% of the game reserve was classified as suitable or moderately suitable, which highlights the limited availability of optimal mating habitats. These areas should be prioritized for protection and possibly expanded through habitat restoration or connectivity measures. The model further supports previous findings indicating that Bezoar goat preferentially use steep slopes, particularly in areas with higher predator risk, where such terrain offers greater safety and refuge (Uçarlı, 2016). Similarly, a habitat suitability study conducted in Iran identified distance to rocky areas, slope, and distance to water sources as the most influential factors shaping the species for habitat preferences across different seasons (Morovati *et al.*, 2014). The model results align with previous studies conducted in northeastern Türkiye, which also reported higher suitability in steep and rugged terrain (Uçarlı, 2016). Similarly, research from Iraq confirmed that land cover, elevation, precipitation, and temperature are among the most influential variables

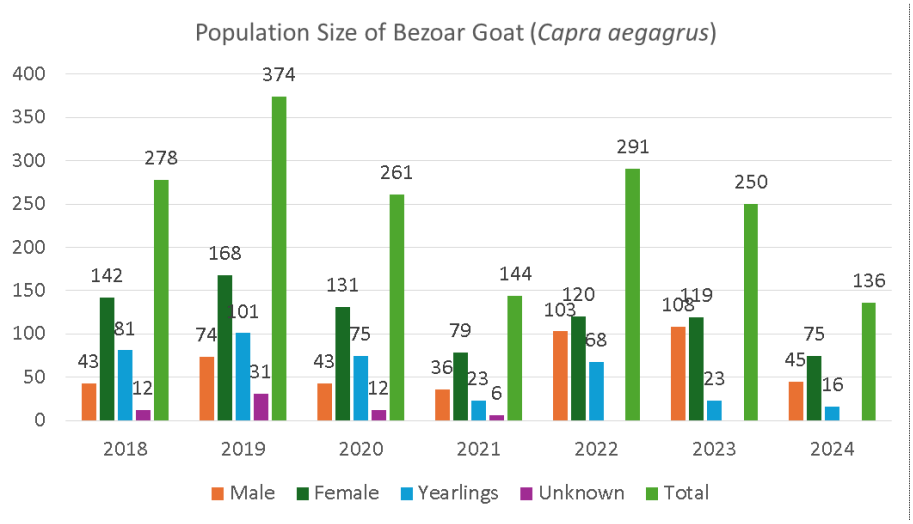


Figure 7: Inventory results of Bezoar goat in the Artvin-Meydancık Game Reserve.

affecting Bezoar goat distribution (Rahim, 2016).

It assumption that the availability and extent of areas suitable for young individuals have a more limiting effect on population size compared to areas used by older individuals (Halpern *et al.*, 2005). Therefore, it is recommended that conservation and planning efforts prioritize the protection of habitats used by young individuals over those used by the population as a whole.

The study area encompasses different elevation zones, which, together with the presence of coniferous and mixed forests, provide diverse habitats such as alpine meadows and alpine rocky areas. The area contains coniferous and deciduous forests, mixed forests, and forest clearings, creating a mosaic habitat structure. Streams in the area form edge habitats through their interaction with forests and grasslands, supporting both high wildlife diversity and the coexistence of different habitat types. So, field observations showed that bezoar

goats particularly prefer steep areas with coniferous forests interspersed with forest clearings. Oak forests are also used by the species especially during the mating season.

Population Density of Bezoar Goat

Studies conducted in other regions of Turkey where bezoar goat occur have reported varying population densities. Population densities have been estimated in other regions: Isparta region; 1.49 ind./100 ha (Gündoğdu, 2006), Artvin-Yusufeli Çoruh Valley wildlife reserve area; 4.62 ind./100 ha (Uçarlı, 2016), Cehennem deresi wildlife reserve area; 2.5 ind./100 ha (Gundogdu, 2011) and Kirthar National Park, Pakistan; 11.8–16.3 individuals/100 ha (Edge & Olsonedge, 1990). For the Iberian wild goat (Capra pyrenaica), population density was reported as 3.6 ind./100 ha during the mating season and 4 ind./100 ha after parturition (Torres *et al*., 2014). The low ecological population density (1.52 ind./100 ha) within suitable areas in the study area, compared to other regions may indicate resource limitations, poaching pressure, or habitat degradation.

CONCLUSION

A habitat suitability model for the bezoar goat was developed using the MaxEnt method for mating habitats. According to the model, 16,304 ha, representing areas with ≥50% suitability, accounted for 27% of the total area, while 43,400 ha, with <50% suitability, represented 73% of the total game reserve. The AUC value of 0.923 for the training data in the model's sensitivity curve indicates high predictive power, demonstrating that the model is highly effective in identifying suitable mating habitats for the bezoar goat.

The most suitable habitats for the bezoar goat were found at elevations between 400 and 1100 m. Sloped areas were more favorable for the species, whereas areas above 2500 m showed lower suitability for the mating season. In addition to bioclimatic variables, elevation, slope, land cover, and forest characteristics had the greatest influence on the habitat suitability model.

The bezoar goat population in the study area was estimated at an average of 248 individuals, with a population density of 0.41 individuals/100 ha across the entire area. Considering only areas with ≥50% suitability, the ecological population density was estimated at 1.52 individuals/100 ha. When compared to population densities reported in other regions of Turkey, this value is considered relatively low.

It is expected that conservation planning in the game reserve can be made more effective by using this habitat suitability model. Furthermore, this study is anticipated to provide practical guidance for sustainable natural resource use and to support management planning in the game reserve by incorporating habitat suitability assessments, offering planners and practitioners new perspectives.

REFERENCES

T.C. Tarım ve Orman Bakanlığı, Doğa Koruma ve Milli Parklar Genel Müdürlüğü. (2020). *Artvin ili Şavşat ilçesi büyük karnivorların yönetimi projesi sonuç raporu.*

Acarer, A. (2024). Yaban Keçisi (Capra aegagrus Erxleben, 1777) Habitat Uygunluk Modellemesi ve Haritalaması: Akdeniz Bölgesi Örneği. 21. *Yüzyılda Fen ve Teknik, 11*(21), 22-31.

Booth, T. H., Nix, H. A., Busby, J. R., & Hutchinson, M. F. (2014). BIOCLIM: the first species distribution modelling package, its early applications and relevance to most current MAXENT studies. *Diversity and Distributions, 20*(1), 1-9. https://doi.org/10.1111/ddi.12144

Çanakçıoğlu, H., & Mol, T. (1996). *Yaban Hayvanları Bilgisi.* İstanbul Üniversitesi.

Edge, W. D., & Olsonedge, S. L. (1990). Population Characteristics and Group Composition of Capra-Aegagrus in Kirthar-National-Park, Pakistan. *Journal of Mammalogy, 71*(2), 156-160. https://doi.org/Doi 10.2307/1382162

Gundogdu, E. (2011). Population Size, Structure and Behaviours of Wild Goat in Cehennemdere Wildlife Improvement Area. *Asian Journal of Animal and Veterinary Advances, 6*(6), 555-563. https://doi.org/10.3923/ajava.2011.555.563

Gündoğdu, E. (2006). *Isparta Yöresinde Yaban keçisi Capra aegagrus Erxleben 1777' nin Popülasyon Ekolojisi,* [Doktora Tezi, Süleyman Demirel Üniversitesi]. Isparta.

Halpern, B. S., Gaines, S. D., & Warner, R. R. (2005). Habitat size, recruitment, and longevity as factors limiting population size in stage-structured species. *The American Naturalist, 165*(1), 82-94.

Kuemmerle, T., Bluhm, H., Ghoddousi, A., Arakelyan, M., Askerov, E., Bleyhl, B., Ghasabian, M., Gavashelishvili, A., Heidelberg, A., Malkhasyan, A., Manvelyan, K., Soofi, M., Yarovenko, Y., Weinberg, P., & Zazanashvili, N. (2020). Identifying priority areas for restoring mountain ungulates in the Caucasus ecoregion. *Conservation Science and Practice, 2*(11).

Larson, M. A., Thompson, F. I. I. I., Millspaugh, J. J., Dijak, W. D., & Shifley, S. R. (2004). Linking population viability, habitat suitability, and landscape simulation models for conservation planning. *Ecological Modelling, 180*(1), 103-118. https://doi.org/10.1016/j.ecolmodel.2003.12.054

Magomedov, M. R. D., Akhmedov, E. G., & Nasrulaev, N. I. (2002). Spatial distribution of the bezoar goat Capra aegagrus (Artiodactyla) population in the Eastern Caucasus. *Zoologichesky Zhurnal, 81*(8), 1008-1016.

Morovati, M., Karami, M., & Kaboli, M. (2014). Desirable areas and effective environmental factors of wild goat habitat (Capra aegagrus). *International Journal of Environmental Research, 8*(4), 1031-1040.

Muñoz, A. R., Jiménez-Valverde, A., Márquez, A. L., Moleón, M., & Real, R. (2015). Environmental favourability as a cost-efficient tool to estimate

carrying capacity. *Diversity and Distributions, 21*(12), 1388-1400. https://doi.org/10.1111/ddi.12352

Rafatpey, P., Lahout, M., Rahnavard, A., Biklarian, H., & Jafarzadeh, M. (2023). Ground squirrels (Spermophilus fulvus) habitat suitability using MaxEnt and ENFA modeling approaches. *Sustainability and Biodiversity Conservation, 2*(1), 6-19.

Rahim, M. (2016). Influence of Environmental Variables on Distribution of Wild Goat (Capra Aegagrus), in Iraq by Maxent. *American Scientific Research Journal for Engineering, Technology, and Sciences, 18*(1), 97-107. https://asrjetsjournal.org/index.php/American_Scientific_Journal/article/view/1542

Süel, H. (2014). *Isparta-Sütçüler yöresinde av türlerinin habitat uygunluk modellemesi* [Doktora Tezi, Süleyman Demirel Üniversitesi]. Isparta.

Torres, R. T., Herrero, J., Prada, C., Garcia-Serrano, A., Fernandez-Arberas, O., & Garcia-Post, R. (2014). Estimating the population density of Iberian wild goat Capra pyrenaica and mouflon Ovis aries in a Mediterranean forest environment. *Forest Systems, 23*(1), 36-43. https://doi.org/10.5424/fs/2014231-03322

Uçarlı, Y. (2016). *Çoruh Vadisi ve Verçenik Dağı yaban hayatı geliştirme sahalarındaki barajların yaban keçisi üzerine etkileri*, [Doktora Tezi, Artvin Çoruh Üniversitesi], Artvin.

Yackulic, C. B., Chandler, R., Zipkin, E. F., Royle, J. A., Nichols, J. D., Grant, E. H. C., & Veran, S. (2013). Presence-only modelling using MAXENT: when can we trust the inferences? *Methods in Ecology and Evolution, 4*(3), 236-243. https://doi.org/10.1111/2041-210x.12004

Yüksel, N. A., & Ambarlı, H. (2024). Artvin Şavşat'ta bozayı habitat uygunluğunun MaxEnt yöntemi ile belirlenmesi ve yönetimi için öneriler. *Düzce Üniversitesi Orman Fakültesi Ormancılık Dergisi, 20*(1), 413-427.

Zenbilci, M., Özdemir, S., Çivga, A., Ünal, Y., & Ogurlu, I. (2024). Habitat Suitability Modeling of Wild Goat (Capra aegagrus Erxleben, 1777) in Different Periods. *Sumarski List, 148*(5-6). https://doi.org/10.31298/sl.148.5-6.5